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# CORONIUM

By GEORGE C. CLARIDGE

HARDLY a total eclipse of the sun occurs without some important observations being made which add to our knowledge of the atoms. The two total eclipses of 1868 will always be remembered for the discovery on the sun of the new element, helium. Although it was not found on the earth until some years later, we have learned much about this element and have even made it play an important part in the development of aeronautics. The helium problem is one of the best examples of theory interpreting observation and of observation substantiating theory. The physicist, in his laboratory, tumbles on the solution to celestial problems: the astronomer, searching the celestial bodies and finding atoms in new environments, illuminates the dark places in the field of physics.

The eclipse of August 7, 1869, which was visible from Alaska to North Carolina, gave the astronomers and the physicists a problem which is almost as far from its solution to-day as it was 68 years ago. During the eclipse, Harkness and Young discovered an emission line of feeble intensity in the green part of the spectrum. Young[1] identified the line as the Fe line No. 1474 on Kirchoff's scale. If this identification were correct it was surprising that only a single line of the hundreds of iron lines should be observed in the coronal spectrum and that it should appear at such great heights. Young was well aware of this great difficulty which at times served to mislead rather than to offer a clue to identification. There were many other cases of lines of different metals coinciding exactly or at least so closely that no instruments at that time were capable of resolving them.

[1]Proceedings of the Royal Society, XXVIII, 475, 1879.

Although Young completely dispelled the idea from his own mind that the green coronal line was due to iron, he could not give up the thought that it might have some very definite relation to it.

The eclipses which followed that of 1869 gave evidence of other lines which could not be satisfactorily identified and were thought to have some relation to the green line in question. Certain groups of these lines had wave-length ratios which served to strengthen the assumption that they arose from a common substance. Some scientists became very skeptical about such scientific procedure and criticized Young's wave-length scale and methods very severely. Many others, including Mascart, Stoney, Salet, and Cornu, worked on this problem in a similar way trying to establish suitable ratios between the unknown lines and those due to hydrogen, lithium, and magnesium.

Young's discovery in 1876 that Kirchhoff's "1474" line was double did not seem to help the state of affairs. It was very certain by this time that the green coronal line was not of terrestrial origin as some had thought it to be. Liveing and Dewar[2] made a comparison of the iron spectrum in the laboratory with the solar spectrum and gave evidence which seemed to prove for a while that the coronal line was identical with one of the iron doublet. Little confidence, however, was placed in this work. Observations were made at every opportunity in order to increase the small amount of available data for theoretical and for laboratory work on identification.

Reliable spectral observations were not obtained until 1893. At the time of the eclipse of 1898, measurements of the green line showed that for the past thirty years identity had been assumed with the chromospheric line 1474 at 5316.8 A. while in reality the green coronal line was approximately 14 A. units toward the violet end of the spectrum at about 5303 A. This more accurate determination of the wavelength of the line due to a hypothetical element called "coronium" was made possible by using instruments of better definition and higher dispersion.

During the next few years many observations were made especially by English and by American astronomers in an effort to obtain better determinations of the wave-length of the coronal lines and in

[2] *Ibid.*, XXXII, 230, 1881.

particular the line at 5303A. The emphasis on the observations of the green line is characteristic of the entire history of coronium. Grotrian[3] has found that the 5303 line is stronger than all other coronal lines combined. He also shows that all the coronal lines, including 5303, contain only 1/160 of the total coronal energy and therefore do not sensibly affect the colour of the corona.

Frost, Dyson, Fowler, Lockyer, and many others made early determinations of the wave-length of the green line.[4] More recent values have been obtained by Campbell and Moore, Curtis and Burns, Davidson and Stratton, Grotrian, and Mitchell with various degrees of accuracy. At the present time, it is difficult to say which are the best. It appears that the mean values of the determinations made by Campbell and Moore, and by Adams, St. John and Ware in 1918 are in very close agreement with the 1930 determinations of Mitchell. The 1918 determinations gave the value 5302.93A. while the ones made in 1930 yielded 5302.91A. These observations also showed that the green line arises in a region within 200,000 kms. of the sun's edge. The *Revised Rowland Tables*, 1928, page 226, gives another list of lines of probable coronal origin. At the present time there are about 18 lines which are thought to be of the coronal group of which one or two are very suspicious.

Along with the observations of wave-length are generally included intensity values. Since these are taken into consideration many times in attempts to construct suitable wave-length ratios among the lines, it is well to be somewhat cautious about their use. We must remember that the values are relative and depend on various factors such as colour sensitivity of the photographic plate, dispersion of the optical system, whether or not a prism or grating is used and whether or not a slit is used. Unless these factors are constant, the intensity values given by various observers are almost useless.

Two ingenious methods have been used in attempts to obtain values of higher precision for the given line. Wright and Curtis[5] have employed the interferometer. Observations were begun by Wright in 1923 and have been continued by both men up to the

[3] *Zeitschrift für Astrophysik*, VII, 26-45, 1933.
[4] *Lick Observatory Bulletin*, X, 1, 1918.
[5] *Journal Optical Society of America*, XXI, 154, 1931.

present with no definite positive results. After the eclipse of 1926, the coronal line 3388A was suggested for use in preference to 5303A because of the decreased intensity of scattered radiation. The problem of the isolation of the desired coronal radiation was very important and was accomplished to some extent by the use of a filter or by a combination of prismatic dispersion and a filter. It appears at the present time that a good filter is the more suitable. At best the lines are faint and are not easy to record under high dispersion. Except for perhaps one case the results are mostly negative. The future work in this method of approach to the problem will be carried on using only the line at 5303A. because of the impossibility of adjusting the optical train in the field if the 3388A. line is used. The low optical efficiency of the étalon is something that must be compensated for by the use of larger ones than have been employed in the past. In spite of the apparent failure of the interferometer determinations, another attempt is to be made at the next total eclipse before entirely rejecting this method as a means of solving the problem of accurate determination of the wave-length of the green coronal line.

Shane,[6] during the eclipse of 1932, used a Fabry and Perot étalon interferometer without success. He points out a very important fact that may be partially the reason why interferometer determinations have been unsuccessful. On account of an appreciable width of about 1A. the 5303 line necessitates small separation of the interferometer plates and therefore a low dispersion. At least a one millimeter separation should be used to get distinct fringes. This is almost too small to be of any value in wave-length determination but might give some information regarding inner coronal motions.

Lyot[7] in 1930 and 1931, observed the green line without an eclipse at a high altitude at Pic du Midi and obtained a value of $5303.2 \pm 1$A. He also recognized the fact that the accuracy was limited by the width of the line but owing to the fact that by this method he was able to make a larger number of observations, the probable error may be greatly decreased and the precision of observation may reach a state superior to that obtainable at the time of an eclipse. The method of Lyot requires observing conditions which are seldom available and the cost of such work is equal to that of

[6] *Publications A. S. P.*, XLIV, 358, 1932.

an eclipse expedition. All things considered, it appears that eclipse observations are still the best. The most recent determination by Lyot[8] in 1935 with a coronagraph gives a value of 5302.83±.02A. for the green line.

Observations, other than those for wave-length determinations, have yielded many interesting facts. Slitless images of the strong coronal lines at 5303 and at 6374 give us structural details resembling eruptive prominences. The images also reveal condensations in the green coronium ring but these are not related to the prominences. The line at 3601 exhibits many peculiarities. During the eclipse of 1908 the line was very strong and like some others it was missing during previous eclipses. The reason for the change in line intensity does not seem to be known. Some propose the sun spot cycle as its cause. However, since the eclipse of 1908 the 3601 line has been visible without exception.

In 1918 V. M. Slipher[9] observed a green line in the space occupied by the moon's image. This scattering was due, perhaps, to the same factors as in the case of H$\beta$ and H$\gamma$. Coronium appears relatively abundant in those regions of the sun's limb from which the great extensions of the corona flow. Certain observations of 5303 have indicated that the substance may at times extend about a solar diameter above the sun's surface. The 1930 slitless observations show that coronium has an uneven distribution around the sun and that the eruptive prominences given by the 5303 line resemble very closely those given by the 3388 line.

The observation of the 5303 line has been confined primarily to the solar corona with one exception, discounting the unconfirmed reports of certain French and Italian scientists that coronium has been detected in terrestrial volcanic gases. In 1933, Adams and Joy[10] obtained definite evidence of the presence of 5303, 6374, and three other coronal lines in the spectrum of the nova-like star, RS Ophiuchi. Since the star is of the 11th visual magnitude, low dispersion had to be used with a consequent low degree of accuracy in

[7] *Comptes Rendus*, CX, 943, 1932.
[8] *Ibid.*, CCV, 1261, 1935.
[9] *Astrophysical Journal*, LV, 73, 1922.
[10] *Pub. A. S. P.*, XLV, 301, 1933.

wave-length determination but sufficiently high enough for identification purposes. The structure of 5303 appeared much like HeII at 4686. However, by April 1934, the continuous spectrum had increased and the coronal spectrum had disappeared.[11] Many forbidden lines of FeII appeared and the spectrum had assumed a general form similar to that of July 1923, before the outburst.

At about the same time, H. D. and H. W. Babcock[12] found the emission line of 5303 present in the flash spectrum taken without an eclipse. Its presence was detected in the high chromosphere—a region characterized by the lines of HeI. Hylleraas,[13] however, has found that there is no quantitative agreement that the coronal spectrum is due to helium.

Since the discovery of the green line in 1869, we find many theories and conjectures as to the element which is responsible for the production of the coronal line. The idea of iron, as the contributing element, was always held with suspicion and definitely dropped as soon as accurate wave-length determinations were made. It was not until 1911 that we have one of the most extensive attempts to solve the mystery of coronium. J. W. Nicholson,[14] who had done outstanding work in accounting for some of the coronal lines by using the element Nebulium (Nu), employed a similar method and dealt with the problem in terms of a dynamical theory of a hypothetical element. The formula used was of the type $\lambda = a(n+\mu)^3$, where n is an integer. The new substance which he called "protofluorine", differs from nebulium only in the fact that it has a central positive charge of 5e, while nebulium has a positive central charge of 4e, e being the electronic charge. The new element was to be electrically neutral with 5 electrons located at an equal distance from the centre and travelling in circular orbits.[15] Nicholson soon found that 5303 was not a protofluorine line and that his new element was not the coronium of the astrophysicist. An increase in the accuracy of the wave-length values of other lines used in developing the theory

[11] *Ibid.*, XLVI, 233, 1934.
[12] *Pub. A.S.P.*, XLVI, 132, 1934.
[13] *Zeit. Physik*, LXIX, 361, 1931.
[14] *M.N.R.A.S.*, LXXII, 49, 1911.
[15] *Ibid.*, LXXII, 139, 1911.

did everything but improve the fit of the formula. Some lines used by him are of doubtful coronal origin or even existence and some have even been identified as chromospheric lines due to FeII and TiII. The model used by Nicholson was a type very different from the Rutherford model, but we must bear in mind that this was the first attempt ever made to explain spectral series by means of Planck's quantum theory of radiation. At the present time, the work of Nicholson possesses only historical or academic interest.

Pannekoek,[16] in 1924, suggested that because of the presence of CaII in the far solar atmosphere CaIII might be the source of the coronal lines. However, J. A. Anderson[17] shows that while 12 weak lines can be matched with CaIII, the 5303 line has no match.

An attempt to show that the lines might be due to argon was made by I. M. Freeman[18] in 1928. Up to this time, lines of unknown origin had been discovered not only in the solar corona but also in the Wolf-Rayet stars (O-type in the Draper Classification), in novae, and in nebulae; and bands of unknown origin were observed in cometary and planetary spectra. I. S. Bowen[19] solved the nebulae problem fairly well. Eight strong lines in the nebular spectra were found to be transitions from the metastable states of NiII, OII, and OIII. The weaker lines were most probably due to metastable transitions in the more highly ionized atoms of the same substances. Fowler[20] in 1909 showed that some cometary bands can be produced in the laboratory by carbon compounds under low pressure (0.01 mm.). Others show that COII is the emitter. Some lines still remained unidentified. The Wolf-Rayet stars, novae, and planetary unknowns are not yet adequately explained but the consensus of opinion is that these radiations arise from familiar substances.

Freeman shows correspondence of over half of the coronal lines with argon within the accuracy of the wave-length values and about 10 more coronal wave numbers were given by intercombination of Messier's term values for argon. The possibility of accidental coinci-

[16] *Bulletin Astronomical Institute of the Netherlands*, Nos. 19, 21, 1922.
[17] *Astrophysical Journal*, LIX, 76, 1924.
[18] *Ibid.*, LXVIII, 177, 1928.
[19] *Ibid.*, LXVII, 1, 1928.
[20] *M.N.R.A.S.*, LXX, 176, 1909; LXXI, 484, 1910.

dence was bothersome. Line 5303 could not be accounted for. It was believed that a line could probably be produced by two different changes in the configuration of the radiating centre and the great intensity of 5303 could be connected with this possibility with a doublet structure with a $\Delta\lambda$ of 0.1A. Eddington[21] had previously pointed out that the stimulating radiation is so weak that the atom is unlikely to absorb a quantum during the full duration of the metastable state and concluded that under such conditions, metastable transitions are not involved here. He also remarked that the density may be low but incident radiation is so intense that if metastable states are concerned at all they must be of short life.

During the eclipse of 1929 a search was made, with no success, to determine whether 5303 was a doublet. Russell and Bowen[22] made a critical study of Freeman's work and found that the number of coincidences was a little larger than might be expected from pure chance within the very wide limits of errors which had been admitted. The discordance for the better measured lines greatly exceeded the limits of observational error and they concluded that the correlation with argon was without foundation.

E. M. Lindsay[23] investigated over 500 forbidden line possibilities of FeII, CaII, TiII, TiIII, ArII (which does not exist in the chromosphere), and several of TiI but no coincidence was found which might not be a matter of chance. Investigation of second type collisions involving metastable $1\delta$ terms of CaII also gave negative results.

In 1931, the coronal line 6374.2 was found by Hopfield to be identical, within the limits of experimental error, with the oxygen line at 6374.29. This would seem to indicate the presence of oxygen in the solar corona. DeBruin[24] announced in 1932 that it was possible to calculate the line 5303 from laboratory data. He claimed that all of the strongest lines attributed to coronium in the visible spectrum could be connected with the terms of OI. He thought that the Zeeman effect of 6374 might give the nature of the new terms

[21] *M.N.R.A.S.*, LXXXVIII, 134, 1927.
[22] *Astrophysical Journal*, LXIX, 196, 1929.
[23] *Nature*, CXXIV, 94, 1929.
[24] *Naturwisscnshaften*, XX, 269, 1932.

and that possibly the $Sp^4$ configuration played an important part. The calculated value of $\nu$ yielded a wavelength of 5302.70A. which was close to the observed values. This was obtained by using the combination $R—2p^1S_0$. According to this 5577 and 5303 had their origin in the metastable level of neutral oxygen, level $^1S$. He definitely concluded that the mysterious coronium turns out to be OI. Ferichs[25] and Dingle[26] immediately challenged such a statement on the grounds that the correlation was merely accidental and Dingle pointed out that the R-term was based on the assumption that requires verification of existence and therefore the problem remains unsolved.

In 1933, Boyce, McKellar, and Menzel[27] tentatively identified 5303, 3388, 4231, and 4776 with analogous high states of OII. Goudsmit and Ta-You Wu[28] on the basis that coronal lines differ from nebular lines in broadness, predicted that the difference was the result of unusually short lifetimes in corresponding quantum states and that the coronal lines may involve transitions between doubly excited states of such an atom as helium.

This short summary of the more important events in the history of the unknown element "coronium" gives ample evidence that a great amount of effort has been put forth in an attempt to arrive at the solution of the problem and that up to the present time we are more familiar with what it is not than with what it is. Nothing, thus far, has given us even an indication as to whether we are to look for the solution from the physicist or from the astronomer. It will probably be the outcome of the work of both. Improvements in instruments and in methods of observing on the part of the astronomer and a more intimate acquaintance with the atoms under unusual conditions by the physicist will surely aid in the solution of the mystery.

The discrimination between coronal and chromospheric lines and the precise determination of the latter with slit spectrographs is of great importance, and without it, positive identification is hardly

[25] *Nature*, CXXIX, 902, 1932.
[26] *Ibid.*, CXXIX, 902, 1932.
[27] *Pub. American Astronomical Society*, VIII, 6, 1933.
[28] *Astrophysical Journal*, LXXX, 154, 1934.

possible. We should, in the future, give more attention to the similarities in structure as a possible clue to atomic origin. However, we must remember that dissimilarities should not be interpreted always as involving different elements as they might be caused by the same element in different states. A standard of intensity of line measurements is needed before the intensity observations by various observers can be utilized.

Many scientists have despaired at the solution of the problem presented by coronium. It is very true that the past 68 years have yielded little positive information but we must remember that the actual time for eclipse observation which has been placed at the disposal of the astronomer during this period is only a little greater than one hour. The work of the experimental physicist has been that of attempting to match lines. This is certainly not a very direct and forward attack on the problem, especially under conditions which do not begin to approximate those under which we find the lines in question originating. Perhaps due to the rapid changes in our ideas regarding the structure of the atoms and lack of accurate data, the theoretical physicist has only occasionally given attention to the problem. No one knows how long we will have to wait for the key to the riddle of coronium. Its solution may come from a new interpretation of work already done or from a source entirely unsuspected at the present time.

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# ORIGINS OF CHRISTMAS

By the Abbé Chauve-Bertrand*

THE Feast of the Nativity of the Saviour has not existed from the beginning of the Christian era. It was only in the fourth century, or the end of the third, that it appeared at Rome. When it took root there, nobody was in a position to prove that the event had taken place on the 25th of December. Mgr. Duchesne, in *Les Origines du Culte Chrétien* declares that "there is no tradition concerning the date of the birth of Christ". Surprising as the fact may be, it is indisputable, whatever one may say about it. Why, then, has the Roman Church placed the anniversary on this day?

Duchesne thinks that the date of the birth of Christ was arrived at by reckoning from the date believed to have been that of His death. Many Churches in the first centuries, discouraged by the difficulties of calculating the date of Easter in the complicated and uncertain processes of those days, chose the symbolic date of March 25th to commemorate Christ's death, and that of March 27th for His Resurrection. With the former date as a point of departure, and on the supposition that Christ passed an even number of years on earth (since fractions were an imperfection to be eliminated)—Christ's conception was also set down at the spring equinox. And thus, after the nine months of pregnancy, Christ's birth would have taken place on the 25th of December.

Such is the reasoning developed by Mgr. Duchesne, who adds, nevertheless, that the argument would be more valuable if it could be substantiated in some ancient document. Unfortunately it cannot.

The Abbé Vacandard, in his *Études de Critique et d'Histoire*

*From the *Journal of Calendar Reform*, (630 Fifth Avenue, New York City), which also gives the following information: A few months ago there appeared in Paris a 256-page book on the subject of calendar reform, under the title "La Question de Paques et du Calendrier." The author, Abbé Chauve-Bertrand of Nevers, has been a student of the subject for more than a quarter century. He was the secretary of the Commission on Calendar Reform of the International Astronomical Union, whose report became the basis on which the League of Nations first took up the subject of calendar revision.

*Religieuse,* would not admit this explanation whereby the 25th of March would have governed the 25th of December; and it is, indeed, hardly reasonable, considering that the feast of March 25th (Incarnation or Conception) is much later in origin than that of December 25th. "With reason," says Dom Leclerg, the learned collaborator of Dom Cabrol, in the *Dictionnaire D'Archeologie Chrétienne,* Vol. 131, p. 908, "Vacandard maintains that the 25th of December governed the 25th of March." Once more, then, why has the Church chosen the 25th of December?

In all probability, this date was chosen because it was the day of the winter solstice (the 25th exactly, according to the Roman calendar of that time)—a day when the pagan cults at Rome, in Egypt, in Persia and elsewhere celebrated the rebirth of the sun—the feast of the *Natalis Invicti.* The *Invictus* was Mithra, who personified the sun. It is believed that in the third and fourth centuries, when this cult of Mithra had spread very widely, the Church sought to oppose Christ, the spiritual Sun, to the pagan sun god. One finds in the Apologists and the Fathers of that epoch expressions which show such a thought. The Prophets had designated the Messiah as the "Sun of Justice": *Orietur Vobis Sol Justitiae.* When Simon received the Saviour in the Temple, he greeted Him as the Light which was to enlighten the nations: *Lumen ad Revelationem Gentium.* Saint Cyprian calls Christ "The True Sun", and Saint Ambrose cries: "This is our *New Sun",* etc. This metaphorical language was quite frequent in those days. However, the eloquence of the preachers was not enough. Much more effective was the practice of counteracting the pagan ceremony with a Christian solemnity in which was celebrated the birth of the One who was presented as the true Sun. All this is very well explained by Dom Botte, in *Les Origines de la Noël et de l'Epiphanie.*

There is more. The scholarly study of Dom Botte brings to mind that our Christmas crib surrounded by lights and approached with reverence on Christmas Eve, is not without resemblance to a pagan ceremony. According to the testimony of Macrobius and of Saint Epiphanius, the Arabs of Petra, the inhabitants of the Valley of Elousa in Idumea, and certain others in Egypt, had the custom of taking from a sanctuary, at the time of the winter solstice, an idol

of the sun, represented as a new born child, whilst the priests went along in a sort of nocturnal procession and chanted the following: "Korah, the Virgin, has given birth to Aion". *Aion* was the new sun. As to the Virgin "There is no doubt," says Dom Leclerg in the *Nativité de Jesus,* "that the *Parthenos* who was the mother of Helios by this astral mythology, is the *Virgo Celestis,* the fertile virgin."

To get to the bottom of this explanation, it remains to be said who this celestial virgin was. She was simply the one whose name figures in the signs of the Zodiac. We know that the sun, in its apparent annual movement, describes on the celestial sphere, a line called the ecliptic—so named because the eclipses are produced on this line. Now, to indicate the place in this region of the sky where the sun was at a given moment of the year, the first astronomers, Egyptian and Chaldean, divided the ecliptic into 12 equal parts and gave the stars which were in each of these parts, names which were chiefly those of animals, from whence the word Zodiac, from *Dzodia,* animals. These names originated from the most striking phenomena of nature and of the earth present at the time that the sun was in each of these 12 parts. Thus they called that part of the stars in which the sun was found at the time when the lambs were born, *Aries,* or sign of the Ram, or stars of the Ram; stars of the Bull or of *Taurus,* were those under which it was time to put these animals to the plow to till the earth; stars of *Aquarius,* those of the period of rain and the floods of the Nile; stars of *Cancer,* or of the Crab, those under which the sun, having arrived at the middle of its course, began to go back like the crab who walks backwards; stars of *Virgo,* or the Harvest Virgin, those under which young girls were seen in the fields cutting the grain or reaping. And thus, on charts of the Zodiac, the ancient astrologers represent the Harvest Virgin, sometimes as governing the family, and sometimes as holding grain in one hand and a branch laden with fruit in the other. Now, after the harvest season, the stars of the Virgo Constellation descended slowly. When they disappeared on the horizon, the sun, at the winter solstice, was placed as though in the bosom and was born, so to say, in the arms of the celestial virgin at the heliacal rising on the eastern horizon; it was he who, in this guise, was

represented as a child nursed by a chaste virgin, in the astrological pictures of the wise men of Persia.

Let no one be frightened by all this. It is a delight to be able to go back, when possible, to the origins—to follow historical developments and distinguish their outlines: To proceed from the astronomical sun to the spiritual Sun, from the Zodiacal virgin to the Crèche of the infant, from the ancient New Year's gifts to our Christmas Trees. We do not realize fully how much the liturgies owe to astronomy. Pius XI, inaugurating this year the observatory at Castelgandolfo, made an allusion to this in speaking of the "connection which exists between religion and the science of the stars". The date of the winter solstice is naturally indicated to be the time of a great feast. The ancient cults anticipated it. Instead of throwing out the sparks of truth that they possessed, it seems better to gather in everything, and, following the example of the Church in the first centuries to emulate the bee, which collects from all the flowers and distills from them a glowing ambrosia. Concerning the feast of Christmas, the pagan influence cannot be denied; only, the sun, object of the pagan cult, is now but a symbol of Christ for the Christians. One is the pedestal of the other. The lovely feast of Christmas is therefore the day of the rebirth of the sun at the winter solstice and, at the same time, the day when the Church celebrates the birth of Jesus, Sun of Justice, Word made man, with whose birth it is fitting to associate the birth of all men, and thus to have the feast of the Infant-God and the feast of all human infants at the same time. For without the births of the latter, humanity would perish, as the world would perish without the rebirth of the sun at the end of each year.

# RECENT SUPERNOVAE IN EXTRA-GALACTIC NEBULAE

By Frank S. Hogg

FOR many years it has been known that, in general, novae have a fairly uniform absolute magnitude of about –6 at maximum. Such novae have been known from early times; they reach naked eye brilliance rather frequently, and occasionally become conspicuous objects. In 1921 Bailey, from an examination of Harvard plates, concluded that from ten to twenty novae appear in our own Milky Way each year. Hubble systematically searched the Andromeda nebula and other of the closer nebulae, and found novae of a similar type and absolute magnitude occurring in these distant universes. Such novae, at maximum, appear rather brighter than the ordinary bright stars of an extra-galactic nebula, and at maximum give only a very small fraction of the total light of the nebula.

In contrast to these novae, there have been occasionally observed, in the distant nebulae, stars that suddenly increase in brightness till they may equal, or even considerably surpass in brightness, the whole remainder of the nebula. This indicates that they must attain an absolute magnitude of –13 to –16 at maximum. We thus distinguish two quite separate kinds of outbursts, *common novae* and *supernovae*, the latter being about eight magnitudes (fifteen hundred times) brighter than the former.

One of the most notable of these supernovae was the famous bright star that appeared in 1885 in the Andromeda nebula. It reached an apparent magnitude of 7.5, corresponding to an absolute magnitude of –14.7. Such a nova radiates at its maximum, about a hundred million times as much light as our sun, and is the greatest source of energy known. The importance of studying such outbursts is apparent.

From photographs made for various purposes, a few such supernovae—mostly of very faint apparent brightness—were found in some of the extra-galactic nebulae. As these were usually faint and not found till after the maximum was passed, only low dispersion spectra, and very incomplete light curves were obtained. The probable frequency of occurrence of supernovae in any one galaxy could be

estimated, in only an approximate manner, as being not one ten thousandth as great as for common novae.

To solve both the statistical and individual observational problems, the Mount Wilson Observatory undertook, in 1928, a systematic survey of certain rich nebular fields, hoping definitely to find all supernovae which might appear in these nebulae. Hubble and Baade at Mount Wilson, and later Zwicky of the California Institute of Technology, periodically and systematically observed the Coma-Virgo cluster of nebulae. In January, 1936, after seven years of search, their first supernova was detected in N.G.C. 4273. This was only a relatively faint object, of the fourteenth magnitude (absolute magnitude –12.5) but the Mount Wilson observers secured some fair spectrograms and measures of the light curve.

Within the past month, however, Dr. Zwicky's search, at Mount Palomar, has yielded two very fine supernovae. The first of these, discovered on August 28, 1937, occurred in the nebula I.C. 4182, and reached the eighth magnitude. On September 10th he discovered a second supernova, of tenth magnitude. Both these novae were intrinsically very bright, about –16.2 absolute magnitude. Due to the unusually bright apparent magnitudes of these stars, the Mount Wilson Observatory secured excellent series of observations both of the spectra and magnitude.

Preliminary results (Harvard Announcement Cards 427, 429) show that the spectra contain the characteristic nova emission bands, with the great widths of two hundred angstroms. This corresponds to expansion velocities of about seven thousand km. per sec. These novae themselves are several times brighter than the whole galaxies in which they occur.

It is expected that the complete data obtained from these observations will go far in providing the explanations of these greatest scientific cataclysms. The solution of such problems as the high temperatures, source of the vast amounts of energy liberated, possibility of production of cosmic rays, and the cause of the outbursts themselves, has for years awaited good observational material. Astronomers will be pleased that the well planned and patiently continued programmes of the California observers has been rewarded by the discovery of these two bright supernovae.

# AN ASTRONOMICAL PILGRIMAGE

By C. S. Beals

THROUGH the kind permission of the Department of Mines and Resources the writer was recently privileged to attend the meetings of the American Association for the Advancement of Science in Denver, Colorado, and also to visit three southern observatories, the Lowell Observatory at Flagstaff, Arizona, the Mount Wilson Observatory at Pasadena, and the Lick Observatory at Mount Hamilton, California. The method of travel was by automobile, so that it was possible to include a number of items of scientific and general interest which would have been missed had the trip been made by train.

Denver, Colorado, is situated on the plains just clear of the eastern slopes of the Rocky Mountains at an altitude of 5,280 feet. The city presents to the visitor a modern and attractive appearance, though the planning of streets in the business section is somewhat confusing to a motorist entering for the first time. The Association headquarters were located in the Cosmopolitan Hotel near the business centre of the city and the general sessions of the Association were held in the assembly hall of the hotel. Section meetings were held both in the hotel and in nearby buildings, those of the astronomy section convening in the auditorium of the Y.W.C.A.

There were three general sessions of the Association at which lectures of a semi-popular nature were given. The first of these was by Dr. H. M. Evans, University of California, retiring President of the Pacific Section, on "The Development of Our Knowledge of Anterior Pituitary Function". Numerous slides were shown illustrating the important role played by the anterior lobe of the pituitary gland in controlling growth and reproduction, while examples of abnormal development illustrated the helpless dependence of an individual on the proper functioning of his ductless glands.

The second evening lecture was by Professor N. V. Sidgwick of Oxford, on the subject "Molecules". This lecture was of considerable astronomical interest as the lecturer devoted a large part

of his time to a discussion of the conditions necessary for the maintenance of life. He pointed out that the existence of complex molecules and the maintenance of chemical action were only possible within rather narrow limits of temperature and that these conditions could be realized only on the surface of a planet associated with a hot star. He went on to consider the nature of organic molecules and the question as to whether it was possible to visualize a chemistry of life very different from that which we know on earth. He concluded that no atom could take the place of carbon in complex organic molecules, while no other fluid could take the place of water as a medium or "lubricant" for promoting the chemical processes peculiar to life. It accordingly appeared unlikely that if life appeared on other planets it would be radically different from life on the earth. This conclusion referred, of course, to life as a whole and not to any particular genus or species.

The third lecture was by Dr. A. E. Douglass of the University of Arizona and the subject was "Tree Rings and Chronology". Dr. Douglass, who is well known among astronomers as Director of the Steward Observatory, gave a comprehensive discussion of methods of analysis used in the study of rings as developed by him over a period of many years. He pointed out that only trees located on hillsides or other places where seasonal droughts affected the supply of moisture available for their growth, could be used in tree ring dating. Those located in valley bottoms where the moisture was held over from year to year were practically useless. He showed that a period extending over the entire Christian era could be accurately dated by tree rings and there was on view a magnificent composite photograph relating tree rings with contemporary events as far back as the times of the Roman Empire. One interesting application of the science of tree rings was the dating of ancient ruins where wood was preserved either in its natural state or in the form of charcoal; but the most valuable scientific result of the work was the possibility which it offered of gaining an insight into climatic conditions over long periods of time in the past.

The meetings of the Astronomy Section (Astronomical Society of the Pacific) took place on Thursday, June 24, morning and afternoon, in the auditorium of the Y.W.C.A. Approximately forty-five

people were present and there were twenty-two papers on the programme, of which nineteen were presented. A list of the papers follows with brief comments appended in some cases. Fuller abstracts of the papers are being published by the Astronomical Society of the Pacific.

1. *The Present State of Solar Activity.* S. B. Nicholson and Elizabeth Mulders, Mount Wilson. This paper emphasized the unusually great activity of the solar surface corresponding to the approach of sun-spot maximum.

2. *Recent Advances in the Study of Auroral Afterglows.* J. Kaplan, University of California at Los Angeles. Laboratory studies of the auroral spectrum showed marked changes with changes of pressure in the tube and the suggestion was advanced that such changes might eventually be correlated with heights of the aurora in the earth's atmosphere.

3. *Water-vapour lines in the Spectrum of Mars.* Adams and Dunham, Mount Wilson. Observations were taken at a time when lines due to the atmospheres of Mars and the earth were separated by the relative radial velocity of the two bodies. The method was believed capable of detecting an amount of water-vapour of the order of five per cent. of that in the earth's atmosphere. Since no lines were detected it was concluded that the water-vapour content of the Martian atmosphere does not exceed this amount.

4. *The Effect on Prediction for Minor Planets of the Hecuba Group, of Terms not Included in the Berkeley Tables of Perturbations.* A. O. Leuschner, Sophia A. Levy, C. M. Anderson, Ellen Barndollar.

5. *Radial Velocities of Cepheid Variables.* A. H. Joy, Mount Wilson. An account of a completed programme of observation of radial velocities of all galactic cepheids available at Mount Wilson. These observations greatly extend the number of velocity curves of cepheids and give promise of valuable additions to present knowledge of galactic rotation.

6. *Recent Photographic Studies of the Surfaces of Mercury, Venus, Mars, Jupiter and Saturn.* E. C. Slipher, Lowell Observatory. An account of a series of systematic observations of the planets with light of different colours. Various interesting features of the planets were mentioned, in particular the appearance of reddish clouds on Mars which were possibly due to dust suspended in the atmosphere.

7. *A Determination of the Amounts of Carbon Dioxide Present above the Reflecting Layer in the Atmosphere of Venus.* A. Adel, Lowell Observatory. Read by title.

8. *Notes on Interstellar Sodium.* P. W. Merrill, Mount Wilson. A general account of observations in which the relation between intensity and distance as well as the ratio of doublet intensities were discussed. The scatter of points on the distance-intensity curve was large suggesting irregular distribution of interstellar matter. The intensity ratio D2/D1 reached high values for some stars in agreement with results by other observers.

9. *The Sodium Content of the Head of the Great Daylight Comet Skjellerup.* A. Adell, V. M. Slipher, R. Ladenburg, Lowell Observatory. Read by title.

10. *Resolving Power in Planetary Photographs Determined from Photometry of the Image Edge.* J. B. Edson, Lowell Observatory.

11. *f-values for Fe I and Ti I from Electric Furnace Absorption Spectra with a Determination of the Solar Temperature.* R. B. King and A. S. King, Mount Wilson Observatory.

12. *On the Clusters of Small Nebulae Within the Great Perseus Andromeda Stratum of Nebulae.* C. Tombaugh, Lowell Observatory. A discussion of nebulae observed on the plates obtained in the course of the planetary survey in progress at Lowell.

13. *The Spectral Features of Nova Lacertae.* W. E. Harper, Dominion Astrophysical Observatory. A summary of an extended paper by the Victoria observers on the nova, dealing with general changes in the spectrum, velocities and intensities of stellar and interstellar absorption lines, colour temperatures, dimensions of star and shell, and temperatures derived from emission bands by Zanstra's Method.

14. *Apsidal Rotation of the Eclipsing Variable, RZ Cassiopeae.* J. A. Pearce. A period of 18.3 years for the rotation of the line of apsides has been determined by spectrographic methods, while absolute dimensions have been derived from a study of the stellar rotation effect.

15. *A Broad Absorption Line at 4430.5 of Possibly Interstellar Origin.* C. S. Beals and G. H. Blanchet. A description of a line of about 40 angstroms in width, the intensity of which appears to vary with distance and which may be of interstellar origin.

16. *Na I and Ca II in Stellar Spectra.* C. S. Beals. A study of the intensity ratio NaI/CaII over the stellar sequence which indicates that the ratio tends to approach unity for some stars of early type.

17. *A Projection Machine for the Measurement of Stellar Spectrograms.* R. M. Petrie. The projection principle is employed to bring spectrum and micrometer reading on a screen in one plane, eliminating much of the fatigue and eye-strain of measurement without loss of accuracy.

18. *The Spectrographic Orbits of H.D. 109510.* R. M. Petrie.

19. *The Spectrographic Orbit of H.D. 214652.* A. McKellar. These two papers give the elements of two binary stars, one of which has double and the other single lines.

20. *Colour Excess due to Absorption.* D. W. Morehouse, Drake University. A discussion of instrumental methods for the measurement of colour indices of stars by photography.

21. *Colour Indices of Reflection Nebulae.* O. C. Collins, Yerkes Observatory. Read by title.

22. *A Mechanical Demonstration of Elliptic Motion.* N. W. Storer, University of Denver. Description and demonstrations of a machine for the classroom demonstration of elliptic motion of different eccentricities.

On Friday morning a joint session with the American Physical Society was held at which physical problems relating to the ionosphere were discussed. Since this JOURNAL has recently published a series of articles dealing with problems of the upper atmosphere, an extended summary of this meeting would hardly be profitable.

After the conclusion of the Astronomy Sessions a start was made on the journey to Arizona Friday afternoon. A side trip to the top of Pike's Peak occupied a few hours, although owing to fog and clouds the main interest attaching to the ascent was the experience at first hand of the effect on the human organism of an altitude of 14,000 feet. Worthy of some note were a number of unusual natural features in the neighbourhood of Colorado Springs. Presumably because of the fact that much of the weathering is due to agencies other than running water, the beautiful red sandstone of the district often assumed monolithic mushroom-like formations with many curious variations of shape suggestive of human beings or other living things.

The road south led through New Mexico, and even in an article devoted to matters of astronomical interest it is impossible to omit a brief reference to the capital, the ancient Mexican city of Santa Fe. Built by the Spaniards in 1610 it has been the seat of Spanish, Mexican and American governors ever since. The city is dominated by a beautiful and novel type of architecture derived from Indian and Spanish origins and adapted to the modern buildings with remarkable uniformity and good taste. This careful fostering of a style of building, native to the soil and appropriate to the climate of the country, gives to Santa Fe a charm and distinction such as few cities possess.

Among the numerous and varied scenic features of the State of Arizona none holds more fascination for an astronomer than the great meteor crater near Winslow. Although the writer had seen numerous pictures and read many descriptions of the crater, none had produced an impression at all comparable to the actual reality. The crater is located about five miles from the main highway approximately forty-five miles from Flagstaff and its gently sloping sides of a greyish colour as compared with the red of the surrounding plains, form a distinctive land mark which must have attracted the attention of travellers long before there was any understanding of

its nature or origin. The gradual approach by road affords a fine opportunity for studying the contours and making mental comparisons with volcanic craters and those on the moon's surface. It grows in impressiveness with a near approach and as the motor road ascends to the rim it suggests a sizable mountain in dimensions, though it actually rises only a little more than a hundred feet above the plain.

Looking downward seven hundred feet to the floor of the crater we were impressed by the precipitous character of the slopes and the small effect of weathering in the years since the crater was formed. Sheared through and clearly exposed were a number of strata of alternate red and whitish rocks which suggested even to an unpracticed eye that the disturbance which had bared them was of comparatively recent origin. The crater appeared to be fairly symmetrical inside and out and this fact no doubt led the first excavators to dig for the meteorite in the centre. It is now believed, though perhaps not with complete certainty, that the main mass has been located under the rim.

The Lowell Observatory was founded in 1894 by Dr. Percival Lowell, then a brilliant amateur, for the purpose of studying the planet Mars. The history and work of this observatory has been outlined by Dr. Harper in the previous number of this JOURNAL.

Less than two hours north of Flagstaff by road is the Grand Canyon of the Colorado River and it goes without saying that our itinerary was arranged to include a visit to this scenic shrine. Arriving at the village on the south rim in the late afternoon, full advantage was taken of the opportunity to watch the changing colours and varying atmospheric effects as the sun went down over the great canyon. The writer was particularly interested to watch for the celebrated "green flash" at sunset as the clear air and level horizon offered what appeared to be ideal conditions for observation. There was, however, some haze in the air, sufficient in fact to make the sun appear slightly reddish as it dipped below the farther rim of the canyon. As it approached the point of disappearance the reddish colour changed to yellow and then to brilliant green. The theory ordinarily advanced to explain the green flash is that of atmospheric dispersion. If this is correct, then the green should change to blue

at the last moment before disappearance. The fact that the blue was not observed is perhaps due to the steepness of the visibility curve of the eye combined with the brightness of the sky background.

Leaving the canyon, the journey was pursued westward and the Colorado River was crossed at Boulder Dam. The dam is located in a desert area where the heat is intense so that a conducted tour through the tunnels and powerhouses below the dam offered a welcome opportunity to cool off. The artificial lake behind the dam is still only two-thirds full and will take some years yet to fill completely. Only a few of the power units are now in operation though the project as a whole is near completion.

At Pasadena, after crossing the Mojave Desert in the early morning, the writer was kindly entertained by members of the staff of Mount Wilson Observatory. There is probably no place which holds more inspiration for a present-day astronomer than this great institution where the most modern and powerful equipment is matched by some of the best minds of the astronomical world. There are few branches of astronomy that are not actively pursued at Mount Wilson and it is impossible in a brief article to give any complete account of the work carried on there. The two days at Pasadena were spent mainly in interesting and profitable discussions with members of the staff on subjects of mutual interest, in particular interstellar matter, spectrophotometric methods and photo-electric photometry.

A visit was made to the optical shop of the California Institute of Technology where the 200-inch mirror and one of the immense grinding tools could be seen. The mirror was seen through a plate glass window as no visitors are permitted to enter the room for fear of introducing grit or foreign substances which might cause scratches in the later stages of figuring. At the time of our visit the holes in the back of the mirror to take the mechanical supports were being completed. The mirror depends for stiffness almost entirely on the system of ribs cast on the back. The thickness of the glass is to be not more than four inches at any point, a feature which contributes to lightness and rapid temperature adjustment.

Through the kindness of Dr. Joy a pleasant evening was spent on the mountain, visits were paid to the 60-inch and 100-inch telescopes and a fine view of Jupiter was had with the 60-inch in spite of the

rather low altitude of the planet. The easy grades of the new road make a drive up the mountain much less arduous than in former years.

On the way up the coast from Mount Wilson the series of observatory visits was made complete by a day's sojourn at the Lick Observatory on Mount Hamilton. The winding road from the city of San José is about twenty-five miles long and takes about an hour to traverse. During that time there were many opportunities to enjoy the view of the Santa Clara Valley, made famous by Wright in his publication dealing with infra-red photographs of the planets (P.A.S.P. *36*, 239, 1924). The astronomical community on Mount Hamilton is famous for its hospitality and the kindness of Director Wright and other members of the staff made our visit of a day and a night very delightful. A round of calls was made on the various astronomers and some insight was gained into the work in progress which included investigations of radial velocity, open clusters, spiral nebulae and novae as well as some new developments in photo-electric photometry. In the evening visits were made to the telescopes, the main interest being claimed by the magnificent 36-inch refractor made about 1886 by Alvan Clark. We can hardly fail to be impressed by the quality of the work of the early telescope makers when it is realized that in spite of all the advances in scientific technique during the past 50 years, the Lick 36-inch and the 24-inch lenses at Lowell have probably never been surpassed since they were made in the 1880's and 1890's. Not the least interesting feature of the visit to Lick was an hour spent listening to Dr. Wright and former Director Campbell swap humorous stories of the fatigues and difficulties of life on the mountain in the early days when a trip to San José meant an all-day journey by stage coach and when the successful storage of food in warm weather involved various primitive but ingenious methods of cooling by evaporation.

Leaving Mount Hamilton in the morning we arrived at Berkeley by noon and most of the afternoon was spent in visits to the seismological department and the physics department of the University of California. Here the main interest was centred in the radiation laboratory where experiments making use of the cyclotron were in progress. The acceleration of atomic particles such as nuclei of

light and heavy hydrogen atoms to velocities corresponding to energies of 2,000,000 to 6,000,000 electron volts by means of the cyclotron undoubtedly represents one of the most remarkable developments of modern experimental physics.

The induction of artificial radio-activity by bombardment of atoms with high speed particles opens up new fields, not only in physics but also in biology and a new laboratory is being constructed where some of these new possibilities can be tested.

The few hours spent at Berkeley brought to a close a series of contacts with fellow workers in astronomy and other sciences which the writer regards as a very rare privilege and one long to be remembered. Three days more of travel up the coast, brought us to Seattle and then to Victoria.

For obvious reasons this article has not included any extended reference to the scenic features of the route followed although they presented everywhere such a richness and variety as to make each day's travel a real delight. So much so that the writer feels that it would be difficult indeed to think of a pilgrimage where a member of our profession could more happily combine pleasure and profit than in these highland regions between the Rocky Mountains and the Pacific Coast.

Dominion Astrophysical Observatory,
Victoria, B.C.

## NIGHT

Darkness sublime, and in the leafy bowers
A solemn hush of stillness as we rest
Beneath the arched canopy. Fragrance of flowers
Still soothes the drowsy senses. In her nest
Each feathery mother broods in solitude.
The last faint gleam has faded from the west.
Murmurs alone the brook's soft interlude.

How sweet is night, her balmy silences
Safe from the sound of the tempestuous day!
Hymned all the heavens are with harmonies
Of the revolving spheres. In wide array
The sea lies calm and peaceful, lost in dreams
Of the immense infinitudes. Here let us stay
In blissful slumber 'neath Diana's beams.

How beautiful is night,—her leisured calm
Of tranquil halcyon hours! The nightingale
Pours out upon the air her soothing balm
Of liquid melody. In yonder vale
The whip-poor-will repeats his plaintive plea,
Monotonous as some old phrasic psalm,
A lone and melancholy litany.

Sweet night, sweet sleep, sweet dreams! Quiet and still
The slow unbreathing moments move along;
Only some quaint ecstatic cricket stays to trill
His silvery lute and string his tinkling song.
The earth counts o'er again her rosary
Of moon-pale memories, one by one, until
The roseate dawn comes creeping o'er the sea.

Victoria, B.C. ALEX. H. SUTHERLAND.

# METEOR NEWS

**Observations relating to meteors and meteorites are cordially invited.**

## Telescopic Meteor Observations

The requests for telescopic meteor observations, published in the Journal a few months ago, have not met with any striking response. Results have been received from only four observers but it should be noted that poor weather conditions frequently existed on the nights of the international programme so that several members of the Society who attempted to observe were unable to send in a report. The observations received are summarized in the table below.

Telescopic Meteor Observations—*Summer, 1937*

| Observer and Station | Aperture | Field | Magnification | Efficiency | Region Observed | Weather F. | Date and local Standard Time | Minutes Observed | No. of Meteors | Magnitude |
|---|---|---|---|---|---|---|---|---|---|---|
| | in. | | | | | | | | | |
| Jack Grant, Orillia, Ont. | 1.9 | 1°.2 | 33x | 3 | zenith | 4 | Mar. 11/12 23.15—1.17 | 83 | 1? | 9 |
| | 1.2 | 6.9 | 8x | 42 | ξOph | 10 | June 10/11 23.24—0.50 | 60 | 3 | 5, 5.7, 6 |
| | 1.2 | 6.9 | 8x | 42 | $\eta$ Per | 5 | Aug. 8/9 23.18—1.18 | 94 | 0 | |
| Neil McNabb, Jr., Acton, Ont. | 3.0 | 1.0 | 40x | 5 | zenith | 8 | May 11/12 23.06—0.07 | 50 | 0 | |
| D.A.MacRae, Dunlap Observatory | 2.0 | 6.6 | 8x | 105 | k Per | 8 | Aug. 11/12 2.35—3.10 | 35 | 0 | |
| | 2.0 | 6.6 | 8x | 105 | k Per | 10 | Aug. 12/13 0.00—2.00 | 90 | 1 | 6 |
| J. Hugh Pruett, Eugene, Ore. | 2.0 | 7.2 | 7x | 97 | $\eta$ Per | 10 | Aug. 11/12 9.15—10.15 | 60 | 7 | 5, 5, 7, 8, 8, 9, 9, |

The column headings are in most cases self-explanatory. The efficiency of the various instruments has been calculated by the approximate formula $0.6(ad)^2$, where a is aperture in inches and d the diameter of the true field in degrees. The magnitudes given in the last column have been corrected for the light gathering power of the instruments and are true visual magnitudes. Only three of the seven meteors observed in Oregon could be definitely associated with a Perseid radiant and it would appear that the telescopic Perseid meteors were by no means numerous.

THE IEROFEEVKA METEORITE

The following interesting article concerning a new Russian meteorite has been received from Dr. I. S. Astapowitsch of the Moscow Astronomical Institute.—

## A NEW METEORITE OF THE U.S.S.R.

By PROFESSOR P. DRAVERT
*President of the Omsk Meteorite Commission*

This meteorite was found by a young forest ward, Timothy Rospasienko, native of the little village Ierofeevka, Kalinin district, North Kazakh region.

The impulse for this search was given by several articles on meteorites published in the newspaper "The Karaganda Commune" (town Petropavlovsk) in 1935-36. Rospasienko began to look with attention at each stone lying on the ground, comparing its appearance to the description of meteorites he had read. On May 8th of the current year, in walking in the steppe surrounding Ierofeevka, he saw on the shore of a dried-up lake a stone with its lower part sunk 4 to 5 cm. into the salt-marsh ground. This stone seemed to resemble a meteorite. Having learned in the newspaper office the address of the writer, he sent the suspected object to him in Omsk, with the question as to whether it was a meteorite.

The find proved, indeed, to be a meteorite of the group of stony meteorites (dark chondrite). It is an angular piece of irregular shape only partly covered with a fusion crust and intersected by

several fissures. Its size is 8.5 x 10.3 x 14.3 cm.; weight 1,770 gr. On the polished surface of the meteorite we see that the main dark mass of the object is strewn with a multitude of small grains and thin lamina of nickel iron. Moreover, in certain sections there are troilite insertions. Owing to its prolonged stay in unfavourable conditions, the meteorite underwent noticeable weathering. The stone's colour is brown on the surface, with a reddish tint in some places, which is due to the appearance of weathered hydrous and anhydrous oxides of iron.

The magnifying glass shows that in places at the rims of the fissures the crust protrudes slightly due to thickening; this seems to indicate that fissures of this kind began to form on the stone in the atmosphere before the final solidification of the crust. It is quite probable that the stone burst as a result of the discrepancy between the outer and inner temperatures of its parts and fell in two or perhaps even more pieces before reaching the earth's surface.

The inquiry conducted by the writer during his visit to Ierofeevka leads him to believe that the fall of the meteorite took place in February, 1925, on a night with full moon.*

The peculiar character of the weathering of the meteorite is due to this term (12 years) during which the stone was subjected to the conditions of a continental climate in a region with scanty atmospheric precipitation. The geographic co-ordinates of the village Ierofeevka are:—Lat. = 51° 52′ N, Long. = 70° 21′ E from Greenwich.

### Meteor Heights Determined Early in the XVIII Century

It has generally been considered that the first actual computations of meteor heights were made in the closing years of the eighteenth century. In recent correspondence, however, M. Eppe Loreta of Bologna gives two references of great historical interest which he has located in old Italian scientific works. These describe the determination of the heights of two meteors which appeared in 1719 and 1745 respectively.

The first reference is on page 285 of an article "De meteoris

**Note by I.S.A.*—Full moon in Febr. 1925 fell approximately at 7 o'cl. local time on Febr. 9; thus the meteorite probably fell on the night of Febr. 8-9.

quibusdam", in the volume "De bononiensi scientiarum et artium Instituto atque Academia Commentarii", Bononiae, Laelii a Vulpe, 1748. The meteor was observed at Bologna on the evening of Feb. 22, 1719. It was described as of the same size as the moon and as bright as the sun near the horizon. It threw out sparks and smoke. Paolo Battista Balbi, a professor of medicine and physics at Bologna, requested observations of this fireball from the surrounding district. On analysis of these he found that the meteor had passed directly over Vicenza, where a detonation was heard, and was at a height not greater than 20,000 "pas" and not less than 16,000 "pas" (between 18½ and 14½ miles), with a diameter of 3,560 "pieds" (about 3,400 ft.).

The second reference appears on page 464 of an article "De globi cujusdam ignei traiectione" also in "De bononiensi scientiarum—", vol. 2, part 1, Bononiae, 1745. A great meteor appeared on Oct. 13, 1745, at Bologna, and was investigated by Francesco Maria Zanotti, philosopher and physicist. It was red, as large as one quarter of the moon, and had a white tail. From observations collected from various places the height was calculated as 6 "milles" (about 5½ miles), velocity 8,000 "pas" in 6 seconds (1.2 miles/sec.), and diameter 70 "pieds" (about 65 ft.).

The above accounts would indicate that an exhaustive search of old European literature might reveal other interesting references to the early study of meteors by scientific methods. M. Loreta has performed a real service in calling these articles to the attention of astronomers. P.M.M.

# REVIEW OF PUBLICATIONS

*Elements of Physics for Canadian Schools,* by F. W. Merchant and C. A. Chant. New Edition, pp. 666, 5½ x 7½ inches. Toronto, Copp Clark Company, 1937. Price $1.00.

During the last twenty-six years some three hundred thousand high school students in Canada and the United States have acquired their first fundamentals of physics from Merchant and Chant's Ontario High School Physics, or, as it was later designated, the Elements of Physics. With the assistance of Mr. A. C. Lewis, headmaster of the University of Toronto Schools, and Professors Ainslie of Toronto and Lang of Alberta, a third completely revised edition of this work has been prepared.

The book covers the whole field of physics, dealing with the mechanics of fluids and rigid bodies, the properties of matter, heat, sound, light and other forms of radiational energy, and electricity and magnetism. The subject matter has been more finely subdivided than previously, now forming eighty-six chapters, dealing with separate subjects. The treatment is direct, and the explanations are kept closely in contact with experiments and fundamental laws. Over seven hundred figures—both line drawings and half-tones—are used to illustrate the phenomena under discussion. The numerous plates are especially instructive, as they cover a wide range of modern subjects. They are used to show the applications of physical methods in industry and transportation, and include such developments as the San Francisco-Oakland bridge, the Imperial Airways Plane *Caledonia,* Northern Ontario mining and paper plants, and stream-line locomotives.

The earlier editions of this book have had a great influence on the teaching of physics in secondary schools. Amateur students of astronomy, or any other science, will find this an instructive and convenient reference book on the physical basis of science.

F.S.H.

*Eclipses of the Sun and Moon,* by Frank Dyson and R. v. d. R. Woolley. Pp. viii + 160, 6 x 9 inches. Clarendon Press, Oxford, 1937. Price 15 shillings.

This monograph on Eclipses is one of the International Series on Physics. Sir Frank Dyson is lately retired from the position of Astronomer Royal and is a veteran of eclipse observation. The co-author, R. v. d. R. Woolley, is chief assistant at the Royal Observatory at Greenwich.

While eclipses of the sun and moon, especially those of the sun, last for a very short time, they have been intensively observed and studied, and the authors have brought together in a very compact way, the methods of observation, theory and results which have been obtained since eclipses have been observed.

The first four chapters deal with the predictions of eclipses and include all that is necessary for the detailed preparation for the observation of an eclipse at any station. The treatment is brief but sufficient. Chapters V and VI discuss the eclipses of the moon and the scientific results which can and have been obtained from their observation. The remainder of the book deals with the results of solar eclipses. The discussion of the physical state of the atmosphere of the sun as determined from eclipses is particularly good. A very great deal of information is condensed into small space. Practically all observers' work on eclipses receives mention and the authors' discussion of their accuracy and conclusions is very fair. Numerous references give the reader a guide to the original papers.

We fancy the book will remain for many years a standard book of reference on eclipses and will be of great interest both to the amateur student and professional astronomer alike.

R.K.Y.

# NOTES AND QUERIES

**Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.**

## A Visit to Alvan Clark's Workshop in 1861

In a book entitled, "God's Glory in the Heavens", by William Leitch, Principal of Queen's University, Kingston, Ont., dated 1862, is found a chapter devoted to astronomy in America. From it the following extracts are taken:

It was with no little surprise that, on inquiry for Mr. Alvan Clark in Boston, we could hardly find a clue to his residence. America is proud of her great men, but the name of her great optician, familiar to every astronomer in Britain, was almost unknown in his own city. It was after considerable search that we found his residence and workshop in Cambridge, a suburb of Boston. Even in Cambridge it was difficult to find him. Boston, at the time, was loud in the praises of an opera-singer, a native of the city, who was on the eve of starting for England to exhibit her wonderful powers in London, and who afterwards drew forth the plaudits of the passengers in the steamer in which we crossed the Atlantic. There was no such celebrity accorded to the obscure worker in glass, who, with marvellous art and dexterity, was fashioning instruments to extend the limits of creation, and open up to view new worlds and systems. Yet, Mr. Clark was as proud of the limited circle that recognized his labour as the opera-singer was of the applause of the crowd in the steamer or the theatre.

When we reached his neat villa, we were shown to the rear, where stood his observatory and workshop, in a building precisely similar to an old Scottish keep, consisting of a square tower of several stories, with a single apartment in each. The middle story, reached by a ladder, was his reception-room, in which the lighter work was executed. The basement floor was devoted to the heavier and coarser work, and the highest was reserved for an observatory, in which a beautiful equatorial was placed. We came in upon him at an inopportune moment. He was bent on being courteous, but he was evidently preoccupied with some grave care which greatly perplexed him. The cause of his anxiety we soon found to be some tapping going on in the workshop below. Every successive blow seemed to intensify his apprehension, and the rebound of his feelings was something startling when a voice from beneath sang out, "All's right". The tapping was the attempt of his son to detach the greatest lens in the world from the pitch-bed in which it was stuck fast for the purpose of grinding. A blow in the slightest degree too strong would be the destruction of the labour of many months and the loss of some thousands of dollars. Now that the lens was safely detached and the burden removed from his mind, Mr. Clark was free to pour out his genial nature and exhibit

the refreshing enthusiasm of a man whose heart is thoroughly in his work. He pointed with pride to a lens lying before him, the fellow of the one that had caused him so much anxiety. This was the great object of our curiosity, and well might a lover of lenses make a long pilgrimage to see such a sight. It is eighteen inches in diameter, a size far exceeding that of any existing telescope of value. . . . The glass was from Chance, Birmingham, and no defect could be traced in it. . . . .

In Mr. Clark's square keep we hoped to escape for a little the tumult of war. The whole nation was stirred to its depths by the war feeling. . . . It was gratifying to find one man engaged in the peaceful pursuits of science; but even in Mr. Clark's sanctuary the curse of war cast its shadow. For when allusion was made to the commercial aspect of his great undertaking, we found that we had touched upon a delicate subject. The great telescope was ordered by the University of Mississippi, and a munificent price was agreed upon; but the war banished all thoughts of telescopes and of obligations of Southern to Northern States. This southern institution was ambitious of possessing by far the most powerful telescope in the world; but by the stern exigencies of war the money that was to be paid for this expensive toy must go to purchase bread and bullets. . . . .

Mr. Clark started in life as a printer, and afterwards took to portrait-painting, which he still practises to a certain extent as a relaxation from his severer labours. It was not till he was upwards of forty years of age that he turned his attention to telescopes. He was first attracted to the subject, by one of his boys asking his aid in casting a speculum for a small telescope which he had taken a fancy to construct. From that time the boy's amusement became the serious business of his father's life.

While testing the lens above referred to, Clark discovered the companion to Sirius, January 31, 1862. Later it was obtained by the Chicago Astronomical Society and it is now in the Dearborn Observatory of the Northwestern University, Evanston, Ill.

### Business Men and Stars

The following actual conversation is reported by one who was a member of the company:

Around a certain table where business men (very occasionally) make a comment which has nothing to do with business the amateur astronomer is asked:

"What is that bright star in the west these evenings?"

"The *planet* Venus."

"What's the difference between a planet and a star?"

(Brief explanation given of the solar system, during which interruptions occur—How many planets? Which is the nearest to the earth? Which is the largest?, etc.)

"How far off are the stars?"

Before this can be adequately answered along comes a question, "Which is the nearest star?"

We are ready for *that* one—"Our sun." Which brings another question, "Well, how far off is it?"

"About ninety-three million miles. Light, which travels at the rate of 186,000 miles a second, takes about eight minutes to reach the earth."

"What would happen if the sun suddenly went out?"

"Assuming that you mean 'if it suddenly exploded', there would be some interesting by-products; but we wouldn't know of it for eight minutes, because as I said, it takes that long for light to reach us."

(Here developed an argument as to whether the first statement had been eight days, eight hours, or eight seconds. It took about eight minutes and an air of authority, plus some figuring to settle this question.)

"How can those mathematicians be certain about their calculations anyway? It is all guess work when it comes to figures like these."

"Well, what would you think of the calculated distance of Sirius, one of the very nearest stars beyond the sun, from which light takes about eight years to reach us?"

But by this time the business minds are exhausted, and the talk turns to Jack Benny and the stars of the radio firmament.—F.T.S.

C.A.C.

REPORT—VARIABLE STAR AND NOVA SEARCH OBSERVING SECTION—TORONTO CENTRE

During the summer months the following observations were made:

*July.*—Mr. Bert Topham searched three regions for novae, five times each. In the field of variables, Mr. Topham estimated the magnitudes of thirteen stars, while Miss R. S. Northcott made four such observations.

*August.*—Two regions were searched for novae by Mr. Topham; and five regions, each five times, by Mr. Neil McNabb. The same observers estimated variables, Mr. Topham making one and Mr. McNabb, five, magnitude estimates.

Holidays and poor weather greatly hindered the making of observations during the last two months. It is hoped that the fall will find all observers able to carry out more ambitious programmes than ever.

F. SHIRLEY PATTERSON.

# RADIO TALKS OVER CFCT, VICTORIA, B.C.

By W. E. Harper

## *The Mount Wilson Observatory*

(January 19, 1937)

To-night I take you in imagination to the great Mount Wilson Observatory, near Pasadena, California. Here is located the world's largest telescope, 100 inches in diameter, and in a few years there will be on an adjoining peak the 200-inch, now under process of construction.

The existence of this observatory is due largely to the initiative and persevering efforts of George Ellery Hale, for many years its director,—until ill health forced him to retire. Hale started astronomical work during his undergraduate days at Harvard, when he was a volunteer assistant to Professor E. C. Pickering of Harvard College Observatory. Upon graduation in June 1890, he visited the Lick Observatory with his bride and was offered a position there. However, he returned to his home in Chicago where he set up a spectroscopic laboratory. Next year a 12-inch lens was ordered and the Kenwood Observatory was dedicated. In the year following he was invited to join the staff of the University of Chicago, the Kenwood Observatory to become the observatory of the University. Soon after joining he persuaded the University authorities to secure a large telescope which had been the dream of his life. He was able to interest a wealthy Chicago man, Charles T. Yerkes, in the scheme, with the result that we have the Yerkes Observatory, affiliated with the University of Chicago though distant 83 miles from the city. This observatory was dedicated in 1897 with Hale as its director.

Hale's work had been largely connected with the sun and a spectroscopic study of the prominences and other surface details. On a trip to southern California in 1903 he was impressed with the atmospheric conditions and conceived the idea of establishing a solar observatory there. The trustees of the Carnegie Institution were favourably inclined to his plans, whereupon he resigned the directorship of the Yerkes Observatory to supervise the new one, known as the Mount Wilson Observatory.

The site on Mount Wilson at an altitude of 5,760 feet above sea level was not chosen at random. Careful and prolonged tests of the seeing conditions by Professor Hussey preceded its choice. It is 25 miles from Pasadena and until recently the road up the mountain has not been the most inviting to travel. The past couple of years, however, have seen an enormous improvement and now there is a wide hard-surfaced road all the way up.

It was originally planned as a solar observatory and indeed for many years it went by that designation. To that end the Snow telescope was moved from the Yerkes Observatory and set up on Mount Wilson. By means of a clock-driven mirror a beam of rays from the sun falls upon another mirror which in turn produces a large image of the sun. Any portion of this image can then be studied in the spectroscope and the composition and motions of the solar gases determined. The lurid red flames known as prominences which shoot out at times with enormous velocities were among the earliest features studied by Hale at the new observatory. They were found to consist principally of the lighter gases, hydrogen and helium, and were more numerous at times of general sun-spot activity.

It was found that the rays of the sun heated the surface of the earth with consequent shimmering of the solar image so that the best definition was not secured. To overcome these heating effects from mother earth a high tower was built, the clock-driven mirror placed there and the rays reflected down to the ground. The 75-foot tower gave such good results that they soon erected one 150 feet in height. For over twenty years this 150-foot tower telescope has been one of their principal engines of research upon the sun. An image of the sun about 17 inches in diameter is formed at ground level and by allowing the light from any portion of it to pass through a narrow slit to the analyser 75 feet below the ground the character of that particular portion of the sun's surface is revealed.

But even before coming to California Hale recognized that a large reflector for work upon the stars was necessary also. A 60-inch mirror had been cast for him in 1896 and partially finished by Ritchey but lack of funds for the necessary mounting delayed its completion. Eventually the success of smaller mirrors of this type convinced a committee of the Carnegie Institution that such a telescope should be included in the equipment at Mount Wilson. The necessary funds were voted for the completion of the 60-inch and it was installed in 1910. It is devoted not only to pictorial photography of the heavenly bodies but also to the examination of their light by the spectroscope. The mirror gathers up as much light as possible from the rays coming from a star and feeds it to the spectrograph. The light from the star has to pass through so many lenses and prisms that only about one per cent is effective in making its record upon the spectrum plate. Hence comes the necessity of having large mirrors to collect as much light as possible.

Very shortly after this reflector came into operation similar reflecting telescopes were projected all over the world, our own 72-inch being thus started on its way. The need at Mount Wilson for one larger than the 60-inch was soon recognized and funds were secured to finish the 100-inch disk of glass which had been cast for them some time earlier. It was put into operation late in the year 1919. Its construction is on a massive scale, the moving parts weighing 100 tons while the revolving dome weighs 700 tons. Even the glass disk alone weighs 4½ tons.

Another piece of apparatus on Mount Wilson is the large 50-foot interferometer. The purpose of this may be briefly explained. The stars are so far away that even though their diameters are known to be of the order of a million miles or in some cases a few hundreds of millions of miles, the light seems to come to us as from a point source. The nearby planets, such as Venus, Jupiter, etc., show disks like the moon. It was shown in 1890 that by combining light from opposite edges of the star disk, if such there were, interference fringes would result. When in 1920 the most favourable star was examined and parallel beams of its light, coming to earth separated by 18 feet or more, had been brought together the fringes were noted. From these the angular size of the star disk and, under certain conditions, the linear size could be determined. Thus a huge rigid instrument of this type was built which has enabled the Mount Wilson astronomers to measure the actual diameters of many stars.

The survey of the year's work there is almost bewildering. Of course, with a yearly revenue of $600,000 they have a large staff and besides they have excellent machine shops to build new equipment as desired. They recently issued the results of several years' campaign on the distances of the stars, wherein 4,179 stars were investigated and their distances determined.

The primary work on the sun continues unabated. Sun-spots are photographed and the velocities of the uprushing gases determined as well as their temperatures. Around each pair of spots a magnetic field is found to exist with opposite polarities for each spot. The relation between the frequency of sun-spots and terrestrial conditions such as "static" is receiving close attention. It is found that at maximum sun-spot activity, which is due in less than two years now, there is more than the usual amount of short wave-length radiation from the sun. This ultra-violet radiation is the kind that stimulates plant growth.

Probably there has been most publicity regarding their studies of the spiral nebulae, those great universes of stars like our own galaxy. The number of these nebulae appearing on long exposure photographs is of the order of 100,000,000 and they are nearly all receding from us as if the whole system of these aggregations of stars were expanding. What the true explanation may be it is hard to say, but during the past few years an enormous amount of information has been secured concerning them at this California observatory.

While at the observatory in September, I had the privilege of seeing the actual grinding operations on the 200-inch mirror. With good luck it ought not to be more than five years before it will be put into operation on Mount Palomar, the site selected for it.

### *The Solar Cycle*

(June 15, 1937)

I am continuing in a sense my radio talks of a few months ago where I discussed possible connections between conditions upon the sun and phenomena

upon the earth. At our Victoria Observatory we do not carry out any special research work upon the sun; our work is upon the stars, but since the stars are suns we naturally have more than a passing interest in anything new concerning our own luminary, the sun.

The subject is timely inasmuch as we are approaching the time of sun-spot maximum which occurs two years hence. Since the year 1900 maximum sun-spottedness has occurred at the following times, 1906.4, 1917.6, 1928.4 and we are due for the next one in 1939. These figures show that while the period of the cycle is about 11¼ years it does not repeat itself with clock-like regularity; it may come a little early or may be a little tardy. The cyclical character of the increase and decrease in numbers of the spots was established by an amateur, Schwabe, as far back as 1843. Considering all the cycles from that day to our own a value of about 11¼ years is accepted as the average period of the sun-spot cycle.

Sun-spots may be likened to volcanoes on the solar surface or, better still, to huge solar cyclones—whirlwinds in the solar atmosphere, accompanied by pronounced magnetic conditions. While often the spot appears to be single, it is more often double. If you were to think of a strand of rope imbedded in the sun's surface in the form of the capital letter U and were to consider it being rapidly twisted, you would have a very good illustration of the connection between the pairs of a spot group. To be a perfect illustration, the rope would have to be very thick, some thousands of miles in diameter, to match the opening out of which are whirled the gaseous masses from deep down under the surface of the sun.

This gaseous material, which is really a cloud of electrified particles, is shot spirally upward at tremendous velocities and rises to heights of tens of thousands of miles above the solar surface. As it rises it likewise expands and on both accounts it becomes cooler. That is why we see it dark against the hotter background. While the surface itself has a temperature of 6,000°, that within the spot may be less than 3,000°, so we have in these solar eruptions one of the most efficient refrigerating systems imaginable.

Now the sun rotates upon an axis, but its period of rotation is much longer than the 24-hour rotational period of the earth. Moreover, it does not rotate as a solid body. Naturally at the high temperature there is no solid matter; it is gaseous. The surprising thing is that the equatorial regions rotate faster than regions nearer the poles. The period of rotation at the equator is 25 days and the lag is such as we proceed either way from the equator to the poles that at the halfway mark it requires about an additional two days to complete the rotation. Repeating this for the sake of emphasis, points midway between equator and poles require 27 days for a rotation as against 25 days at the equator.

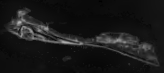
The life of a sun-spot varies greatly. The shortest-lived disturbance is of but a few hours' duration. Many spots, however, persist one, two or more complete rotations of approximately 27 days each. The longest-lived spot on

record is that in the years 1840 and 1841 which persisted for eighteen months. It must have been a big one and very deep-seated.

Spots seem to favour certain positions on the sun and to abhor others. After a period of relative quiescence the spots begin to make their appearance about half way between the equator and the poles, or as we technically put it, in latitudes $\pm 40°$. As time goes on and the spots become more numerous they gradually shift in closer to the equator and at the maximum they are most numerous in the zone centred 15° on either side of the equator. No spots appear within 5° on either side of the equator nor beyond 40° from it. That is to say they occur in a zone with limiting latitudes 5° to 40° on either side of the equator and are rarely ever found outside that zone. Why this should be is a mystery but the vortices set up by the faster moving equatorial regions may have some tendency to weaken the structure in the median latitudes. That is a mere suggestion unsubstantiated by any worth-while data.

In one of these recent talks I told you something about certain effects produced upon the earth by reason of the sun-spots discharging their material in our direction. If conditions are just right,—that is if the spot is on the central meridian and directed squarely towards us and an outburst occurs with sufficient velocity to carry the stream of electrified particles clear of the gravitational field of the sun then we will be in for a bombardment. It requires about 26 hours for the particles to traverse the intervening space and I spoke of some of the resulting magnetic and electrical and auroral phenomena in that former talk.

To-night I wish to tell you of another effect which these outbursts in the solar atmosphere have upon the earth. It concerns radio reception and it would appear that the fade-outs, so annoying at times, are traceable to such outbursts. For slightly over a year now motion-picture photos of the sun have been obtained at Mount Wilson every four minutes and thus the instant of a new eruption can be accurately determined. Another group of workers at the Bureau of Standards, Washington, D.C., have been studying by automatic recording devices the reception of radio signals. It would seem that every time there is a pronounced outburst on the sun there is a definite fade-out on certain wave-length channels. The number of instances of such simultaneous occurrences during the past year is now so great that it is not a matter of mere chance; there is a vital correlation between the two. Unlike the other effects discussed in the previous talk which require the spot group to be directly pointed earthwards this effect happens with the solar disturbance anywhere on the hemisphere turned towards us and it is instantaneous. It is true some exceptions have been found in which there is a lag in time and while the reason is not clear it is suggested that possibly the electrical layers above us, such as the Heaviside layer, are not in the right condition to transmit the impulse immediately. Far-reaching discoveries along these lines are in the offing.



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The Society publishes a monthly JOURNAL containing each year about 500 pages and a yearly OBSERVER'S HANDBOOK of about 80 pages. Single copies of JOURNAL or HANDBOOK are 25 cents.

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**Telescope Mountings for Amateur Builders,** by H. Boyd Brydon, 48 pages; Price 25 cents postpaid.

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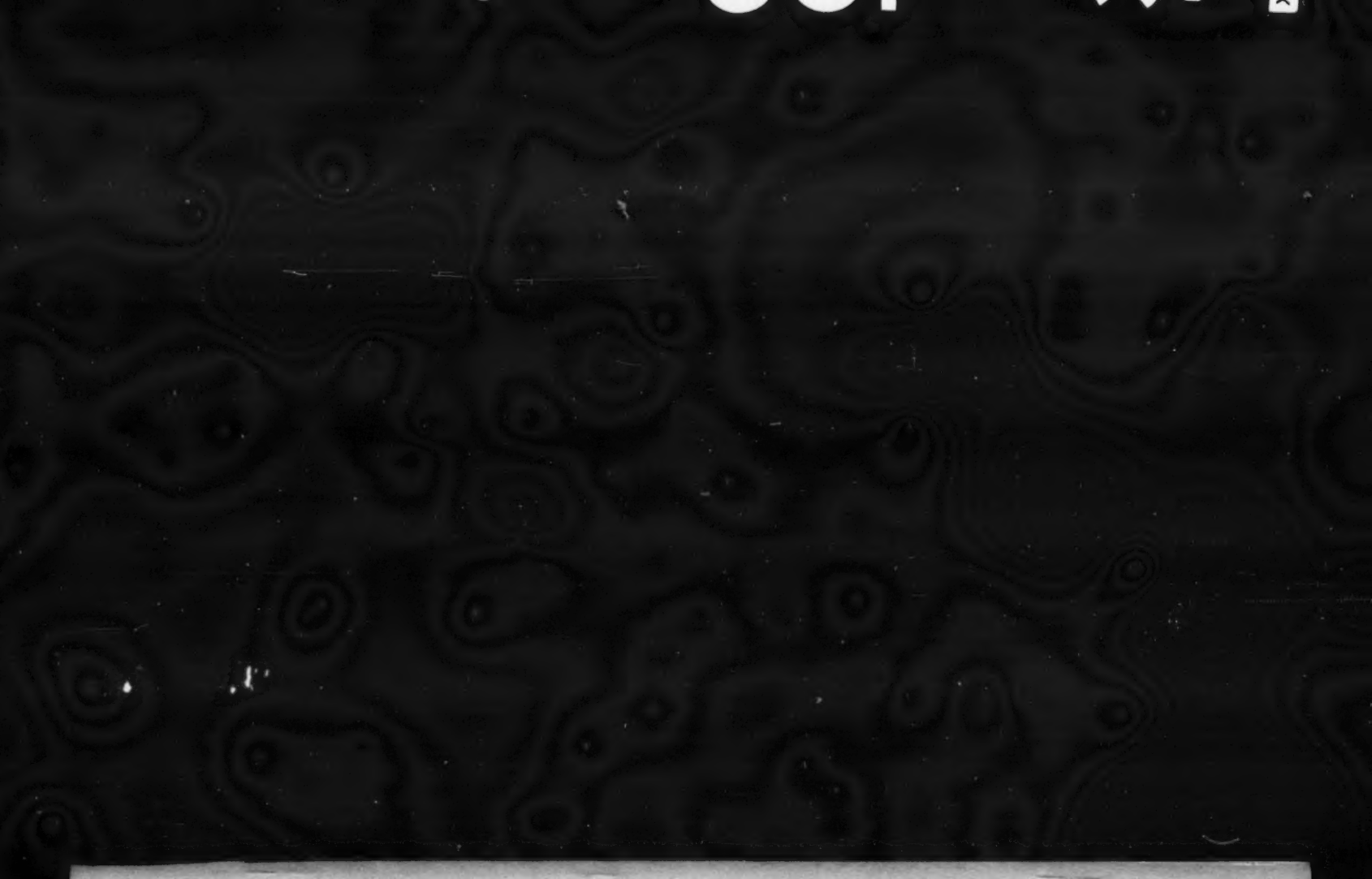
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